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Article

# SDG Implementation through Technology? Governing Food-Water-Technology Nexus Challenges in Urban Agriculture

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**Abstract**
The 2030 Agenda for Sustainable Development emphasizes the importance of technology as a pillar for the implementation of the Sustainable Development Goals (SDGs). Technology innovation promises benefits especially for the implementation of SDG 2 to end hunger, achieve food security and improved nutrition, and promote sustainable agriculture. Contributing to current debates on SDG implementation, technology innovation, and cross-sectoral governance, we argue that technology innovation carries both the potential to contribute to global goal implementation and the risk of posing new governance challenges. Applying a food-water-technology nexus (FWTN) perspective, we conduct a case study on an emerging technology in urban agricultural production in Germany. The technology connects the wastewater treatment system and the agricultural production system and projects the transformation of a conventional sewage treatment plant into a 'NEWtrient®-Center,' which draws the essential resources for urban hydroponic plant cultivation from municipal wastewater. Building on qualitative and participatory research methods, the study provides deeper insights into the governance implications of FWTN issues stemming from the emerging technology. The analysis shows that this technology has the potential to facilitate SDG implementation, but simultaneously fuels new sector interlinkages between water and food and policy demands that substantiate the need for more integrated policymaking to ensure the smart use of technology to reach the SDGs.

**Keywords**
cross-sectoral governance; food-water-technology nexus; Germany; participatory research method; SDG implementation; technology innovation; urban agriculture; wastewater treatment

**Issue**
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## 1. Introduction

The 2030 Agenda for Sustainable Development emphasizes the importance of technology as a pillar for the implementation of the Sustainable Development Goals (SDGs; UN Interagency Task Team on Science, Technology and Innovation for the SDGs, 2018). Technology innovation contributes to more effective global goal implementation, especially regarding the implementation of SDG 2 to end hunger, achieve food security and improved nutrition, and promote sustainable agriculture (UN, 2015). According to the UN Conference on Trade and Development (2017), agri-food technologies address the four dimensions of food security, namely, food availability, access, supply, and utilization. Irrigation technologies can, for instance, increase food availability, post-harvest and agri-processing technologies can improve food accessibility, bio-fortification can make food more nutritious, and climate-smart solutions such as early warning systems can mitigate food instability (UN Conference on Trade and Development, 2017). Innovative agri-food technologies also promise more efficient use and reuse of natural resources (Pigford, Hickey, & Klerkx, 2018). The development of treatment technologies for the safe reuse of water in agriculture is a topical issue (Helmecke, Fries, & Schulte, 2020). In several European countries, e.g., Greece, France, Spain, Italy, Portugal, and Cyprus, the reuse of wastewater for irrigation is common practice (Federal Environment Agency [UBA], 2018). To tap the potential of wastewater for agricultural production, research groups around the world are developing advanced wastewater treatment technologies, such as membrane bioreactors, membrane filtration, advanced oxidation, and ultraviolet disinfection (e.g., Lazarova, Asano, Bahri, & Anderson, 2013), as well as wastewater nutrient recovery technologies (e.g., Xie, Kyong Shon, Gray, & Elimelech, 2016).

This article contributes to current debates on global goal implementation, technology innovation, and cross-sectoral governance (Liu et al., 2015; Pradhan, Costa, Rybski, Lucht, & Kropp, 2017; Sachs et al., 2019). We assume that innovative technologies can contribute to SDG implementation, but simultaneously fuel new sector interlinkages and governance challenges (Schwindenhammer, 2020). Applying a food-water-technology nexus (FWTN) perspective, we conduct a case study on an emerging technology in urban agricultural production in Germany. The technology connects the wastewater treatment system and the agricultural production system. It projects the transformation of a conventional sewage treatment plant into a 'NEWtrient®-Center' which draws the essential resources for urban hydroponic plant cultivation from municipal wastewater.

Following the growing body of nexus studies that directly involve stakeholders in the research process (e.g., Cairns & Krzywoszynska, 2016; White, Jones, Maciejewski, Aggarwal, & Mascaro, 2017; Yillia, 2016), we apply qualitative and participatory methods. We address the following questions: How do FWTN issues arising from the emerging technology relate to existing sectoral policies? How are these issues perceived by policy actors? What are the implications for governance regarding SDG implementation?

This article develops as follows: We start by discussing sector interlinkages between food, water, and technology and current approaches to SDG implementation (Section 2). Then we introduce the FWTN perspective as the theoretical lens for the analysis (Section 3) and highlight the research methods (Section 4). We present findings on the governance implications of FWTN issues and indicate new cross-sectoral governance challenges and demands that substantiate the need for more integrated governance to ensure the smart use of technology in SDG implementation (Section 5). Finally, we discuss the added value of the analysis for research on global goal implementation and cross-sectoral governance (Section 6).

## 2. Food, Water, and Technology Interlinkages and Current Approaches to SDG Implementation

The SDG framework reveals a complex web of sector interlinkages that cause negative (trade-offs) and positive impacts (co-benefits; Nilsson et al., 2018). To ensure SDG implementation, sectoral issues like food, water, and energy cannot be considered in isolation. Most of the food produced today is processed, packaged, and transported over long distances, thereby increasing its energy and water footprints (Yillia, 2016). Water availability and use influence the food and energy sectors and are influenced by them (Martinez, Blanco, & Castro-Campos, 2018). While irrigation in agriculture improves crop yields (SDG 2), increases in agricultural production exacerbate water scarcity and aridity (SDG 6).

Current debates on SDG implementation stress the importance of nexus-based and localized approaches to global goal attainment. While nexus governance is promoted as a way to ensure governance actions that meet multiple SDGs in a coherent way (High-level Political Forum on Sustainable Development [HLPF], 2018; UN Environment Management Group, 2019), localizing the SDGs is discussed as a precondition for achieving them (Carmona-Moreno, Dondeynaz, & Biedler, 2018). The President's summary of the HLPF (2018, p. 13) stresses that progress could be leveraged through addressing the many interlinkages among the SDGs by taking into account the "land-food-water-energy-climate nexus." The localized approach to SDG implementation identifies the local scale as the place where "positive interlinkages amongst the SDGs are boosted" (Siragusa, Vizcaino, Proietti, & Lavalle, 2020, p. 9). According to the United Cities and Local Governments (2019, p. 18), localizing the SDGs includes defining, implementing and monitoring strategies at the local level for achieving global, national, and sub-national sustainable development goals and targets. Cities are regarded as influential "living labs" that develop innovative technologies and promote transformative actions to reach the SDGs (Siragusa et al., 2020, p. 5). The HLPF (2018, p. 7) stresses the importance of technology innovation as part of "bottom-up solutions" and to translate local research findings into policy actions for attaining the SDGs.

This analysis focuses on an emerging technology in Germany that promises benefits for SDG implementation by means of nutrient recovery and reuse and by providing a resilient urban plant cultivation system that is widely independent from changing temperature, water scarcity, or extreme weather events. Extreme weather events and the problems of water scarcity and aridity increasingly pose challenges for agricultural production. The emerging technology is particularly oriented towards SDG target 6.4 to "substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity" (UN, 2015, p. 23) and SDG target 2.4 to "ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production…for adaptation to climate change, extreme weather, drought, flooding and other disasters" (UN, 2015, p. 19). The emerging technology projects the transformation of a conventional sewage treatment plant into a 'NEWtrient®-Center' which draws the essential resources nitrogen, phosphorus, potassium, $CO_2$, and heat for urban hydroponic plant cultivation from municipal wastewater. The technology is the first of its kind and is going to be applied in a model plant with a production capacity of 40 tons of vegetables per year at the sewage treatment plant 'Emschermündung' in Dinslaken (North Rhine-Westphalia). The technology is currently being developed by 15 partner institutions in the joint research project 'SUSKULT,' coordinated by the Fraunhofer Institute for Environmental, Safety, and Energy Technology and funded by the German Federal Ministry of Education and Research.

## 3. Conceptualizing the Food-Water-Technology Nexus

This study focuses on the governance implications of the emerging technology through the theoretical lens of nexus research. We assume that connecting the wastewater treatment system and the urban agricultural production system does not only provide benefits for SDG implementation; it is also likely to raise new cross-sectoral governance challenges and demands.

Classical nexus research provides a valuable theoretical perspective for analyzing synergies and tradeoffs between sectors and how resource systems are managed (Weitz, Strambo, Kemp-Benedict, & Nilsson, 2017). It conceptualizes sector interlinkages as the result of wider transformational processes, such as climate change, urbanization, global trade, and context-specific conditions, such as governance frameworks and cultural beliefs and behaviors (FAO, 2014).

While classical nexus research provides added value for accessing and synthesizing large scale quantitative data on the intersection of various resource systems (Yillia, 2016), it neglects nexus governance implications (Weitz et al., 2017). Even though classical nexus research addresses enabling conditions for circular and restorative technical solutions across different sectors (e.g., wastewater to fertilizer; Carmona-Moreno et al., 2018) and related investments in research, development, infrastructure and planning (UN Environment Management Group, 2019), explaining barriers to achieving policy coherence and integrating different and sometimes competing demands into cross-sectoral governance remain research challenges (Endo, Tsurita, Burnett, & Orencio, 2017).

Building on recent nexus studies that heed the governance implications of sector interlinkages and the importance of stakeholder engagement (e.g., Weitz et al., 2017; White et al., 2017; Yillia, 2016), we apply a FWTN perspective. We seek not only to understand how resource systems are physically interconnected but also how and with what policy effects they are interlinked (White et al., 2017). Following Yillia (2016), we assume that the emerging technology creates a FWTN that interacts with existing food and water policies and contextually interconnects with issues such as people's values, habits and livelihoods.

The FWTN perspective has some merit: First, it broadens the empirical focus of classical nexus studies, which show unequal interest in different nexus dimensions. Due to their perceived importance for economic growth and sustainable development, energy and climate change are more in the spotlight than the dimensions water and food (Yillia, 2016).

Second, it allows conceptualizing technology innovation as a context-specific issue. Different policy systems entail specific environmental, socio-economic, and institutional conditions. Depending on such conditions, policy goals and strategies can vary (Yillia, 2016). While some contexts provide mandates or infrastructures to address FWTN issues in an integrated manner, others are still promoting sectoral policymaking.

Third, it sheds light on policy conflicts and debates over nexus issues (Weitz et al., 2017). Nexus issues result from the commitment of policy-entrepreneurs who strategically raise awareness of policy issues, tap institutional potential, and (re)define policies as issues of political concern (Schwindenhammer, 2017). Since different entrepreneurs perceive different FWTN issues as important and campaign for different solutions, nexus interactions can become conflictual.

Fourth, it allows discussing nexus governance implications. FWTN issues require policies that exceed sectoral boundaries and administrative silos. Balancing policy tradeoffs necessitates integrated cross-departmental decision-making and planning and institutional interplay across sectors, levels, and jurisdictions (Yillia, 2016).

## 4. Methods

For this study, we conduct a case study, building on qualitative and participatory research methods. We derive empirical data from document and website analysis and add background information from five semi-structured expert interviews conducted between October 2019 and March 2020 with representatives from public administration, the water sector and food business (coded as I1–I5). We sampled the interviews to reduce randomness as much as possible. The sample includes principal protagonists from the public and the private sector that participate in local food and water governance and have privileged access to expert information.

Following the growing body of participatory nexus research (Cairns & Krzywoszynska, 2016; White et al., 2017; Yillia, 2016), we also directly involve policymakers, consumers, local wastewater associations, as well as food and agribusiness actors in the research process. We conducted an online survey among project partners (n = 29) in September 2019 and a stakeholder survey at Justus Liebig University Giessen (n = 75) in December 2019. The online survey included a set of open and closed questions about the project partners' perceptions of the overall SUSKULT vision, related risks, and regulatory implications. The stakeholder survey was conducted in the context of an open lecture focusing on food consumption and transparency issues. After introducing the emerging technology, the audience was invited to participate in a written survey including a set of open and closed questions about individual motivations for food consumption and demands for food transparency and sustainability. Data assessment was carried out using the statistical software SPSS.

The findings on stakeholders' perceptions of FWTN issues derived from the surveys were complemented by two focused stakeholder discussions in September and December 2019. The discussions brought together selected experts in charge of local wastewater governance, food business, and sustainability initiatives that shared and discussed expert appraisals and experiences. The findings allowed for further specifying and prioritizing the FWTN research items related to the emerging technology.

## 5. Results and Discussion

### *5.1. Food-Water-Technology Nexus Issues Linked to Water and Food Governance*

The empirical findings reveal that FWTN issues address and challenge water and food governance. Critical issues in water governance are the regulatory focus on surface waters and groundwater (Section 5.1.1) and lacking limit values for contaminants of emerging concern in water reuse (Section 5.1.2). Relevant issues in food governance are food safety and hygiene regulations as well as maximum levels for certain contaminants in foodstuffs (Section 5.1.3).

#### 5.1.1. Water Governance Focus

Even though water governance frameworks address the issue of wastewater reuse, neither EU water governance nor German federal law comprehensively regulate the reuse of water in agriculture (Becker et al., 2017). This applies particularly to broader effects associated with the life cycle of the wastewater system as a whole (Yillia, 2016).

In European water governance, the EU Water Framework Directive (EU, 2000) stipulates that the chemical and ecological status of surface waters and the chemical status of groundwater must not be adversely affected. This has also to be ensured when treated wastewater is used in agriculture. The EU Groundwater Directive (EU, 2006a) stipulates that the introduction of hazardous substances into groundwater must be avoided or minimized. The EU Urban Wastewater Directive (EU, 1991; amended by EU, 1998, Commission Directive 98/15/EC) states that wastewater should be reused where possible while keeping environmental pollution to a minimum.

In Germany, the German Water Resources Act translates the requirements of the EU Water Framework Directive into the German context (Federal Republic of Germany, 2009), while the German Waste Water Ordinance further specifies the implementation of the German Water Resources Act regarding the requirements for discharging wastewater into water bodies (Federal Republic of Germany, 2004). German water policy focuses on the protection of water bodies. It regulates sewage treatment plants to limit their impact on the environment, focusing particularly on eliminating or reducing chemical concentrations in water bodies. Sewage treatment plants have to meet cleaning targets and adapt to requirements regarding the quality of the water bodies into which the treated wastewater is discharged (Neubert, 2003).

In May 2020, after several years of debate, the EU approved the new regulation on minimum requirements for water reuse (date of application 26 June 2023). The regulation addresses the issue of water scarcity, lays down minimum requirements for water quality and monitoring, and sets out key risk management tasks to guarantee that the reuse of treated wastewater in agriculture is safe (EU, 2020). Article 4 touches elements of the emerging technology since it defines minimum requirements plant operators have to comply with before treated wastewater can be used for agricultural irrigation (EU, 2020). However, the regulation only addresses conventional (soil-based) plant cultivation and ignores hydroponic cultivation systems. Hydroponic plant cultivation is critical and calls for a different regulatory focus. Depending on their composition, soils adsorb many pollutants from water. In hydroponic plant cultivation there is no soil and therefore no potential buffer between the plants and the water that can prevent the plants from absorbing pollutants.

All in all, existing water governance frameworks have a different regulatory focus (protection of surface waters and groundwater) thereby widely neglecting the resources available in wastewater for liquid fertilizer production. As yet, existing water governance frameworks only address conventional (soil-based) plant cultivation systems, not paying sufficient attention to soil-less plant cultivation systems (hydroponic).

#### 5.1.2. Limit Values for Contaminants of Emerging Concern

Risks and governance of contaminants of emerging concern in water for reuse in agricultural irrigation are topical issues (Helmecke et al., 2020). In Germany, different groups of substances have been detected in wastewater, such as pharmaceuticals, pesticides, or biocides, which need to be reduced in any case, but even more so when wastewater is used in agricultural irrigation (UBA, 2019). Currently, treated wastewater carries risks of contamination, e.g., with salmonella and bacteria (German Federal Institute for Risk Assessment [BfR], Federal Research Centre for Cultivated Plants [JKI], & Max Rubner-Institut [MRI], 2020) or pathogens, and of not having an adequate concentration of nutrients to allow successful plant production (Neubert, 2003).

When food is grown using treated wastewater, quality requirements have to be suitably high, especially regarding limit values for contaminants of emerging concern. A key aspect is to avoid health risks. With agricultural reuse of wastewater, the requirements for treated wastewater change regarding water quality, treatment, downstream usage, and monitoring of the process and quality (Drewes et al., 2018). Limit values for pharmaceuticals in wastewater are an issue of particular concern (UBA, 2014). These substances are discharged into wastewater not only by humans, but also through livestock farms and veterinary medicine. If treated wastewater is reused in agricultural production, there is a residual risk that plants do absorb pharmaceuticals and their metabolites from treated wastewater (Miller, Nason, Karthikeyan, & Pedersen, 2016). However, the risks posed by the consumption of the affected foods usually remain within the limits or below the threshold of toxicological concern of the European Food Safety Authority (EFSA; Prosser & Sibley, 2015; Riemenschneider et al., 2016).

The new EU regulation on minimum requirements for water reuse does not set limit values for contaminants of emerging concern. It only determines water quality requirements regarding E. coli, BOD5, TSS, and turbidity (EU, 2020, Annex I). It states that minimum requirements "do not preclude food business operators from obtaining the water quality required to comply with Regulation (EC) No. 852/2004 using, at a subsequent stage, several water treatment options alone or in combination with non-treatment options" and clarifies that "the primary responsibility for food safety is borne by the food business operator" (EU, 2020, p. 36).

#### 5.1.3. Food Safety and Hygiene and Maximum Levels for Certain Contaminants in Foodstuffs

If food was grown applying the emerging technology, it would have to comply with food safety and hygiene regulations and legal limits for contaminants in foodstuffs. European food safety regulations and standards provide the legal framework for food production in the member states. The European General Food Law Regulation ([EC] No. 178/2002) lays down general principles and requirements of food law, establishes the EFSA, and specifies procedures in matters of food safety (EU, 2002). The main components of European food safety are the responsibility of entrepreneurs, traceability in the entire food chain, official food control, the precautionary principle, and independent scientific risk assessment, risk management and transparent risk communication to consumers (German Federal Ministry of Food and Agriculture [BMEL], 2018a). Implementation of food safety addresses the entire food chain under the slogan 'from field to fork' and connects different policy issues, e.g., contaminants, animal welfare, plant protection, food production and distribution, and food sector innovation (EFSA, 2012). The food safety responsibility of entrepreneurs implies that producers of food vouchsafe that it is safe for humans (BMEL, 2018a). Still, further clarification of responsibilities of actors involved in food production applying the emerging technology is needed.

According to Chapter VII(3) of the EU regulation on the hygiene of foodstuffs ([EC] No. 852/2004):

> [R]ecycled water used in processing or as an ingredient is not to present a risk of contamination. It has to be of the same standard as potable water, unless the competent authority is satisfied that the quality of the water cannot affect the wholesomeness of the foodstuff in its finished form. (EU, 2004, p. 21)

The German Food Hygiene Regulation explicitly refers to adverse effects on food caused by "human and animal excreta, waste, wastewater, cleaning agents, plant protection products, veterinary drugs, biocidal products or unsuitable treatment and preparation processes" (Federal Republic of Germany, 2016, p. 1).

The German Food and Feed Code authorizes the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) to prohibit or restrict placing foodstuffs which are exposed to contamination of air, water, or soil on the market (Federal Republic of Germany, 2005). According to Controls Regulation (EU) 2017/625 (replacing Regulation [EC] No. 882/2004), national enforcement authorities are to monitor compliance with "food and feed law, rules on animal health and welfare, plant health, and plant protection products" (EU, 2017).

Regarding the emerging technology, maximum levels for certain contaminants in foodstuffs are a critical issue. The EU regulation on setting maximum levels for certain contaminants in foodstuffs ([EC] No. 1881/2006) defines maximum levels for nitrate, mycotoxins, metals (lead, cadmium, mercury, tin), 3-monochloropropane-1,2-diol (3-MCPD), dioxins and dioxin-like polychlorinated biphenyls (PCBs), and benzo(a)pyrene (EU, 2006b). The As Low As Reasonably Achievable (ALARA) principle applies to substances, for which no fixed limit values or maximum levels in food have been set (BMEL, 2020a). The ALARA principle stems from the EU Council regulation laying down community procedures for contaminants in food ([EEC] No 315/93), which states in Article *2*(2) that contaminant levels shall be kept as low as can reasonably be achieved by following good practices at all stages of food production (EU, 1993). However, existing regulations are too vague regarding contaminants that can potentially emanate when applying the emerging technology.

*5.2. Food-Water-Technology Nexus Issues and Policy Demands*

Public and private policy-entrepreneurs raise different demands regarding FWTN issues arising from the emerging technology. The analysis reveals dispute over FWTN issues within and between water and food sectors and across policy levels. Main debates are on the necessity, safety, and cost-efficiency of water reuse (Section 5.2.1), risk assessment and minimum quality requirements (Section 5.2.2), and food supply chain transparency as well as labeling (Section 5.2.3).

5.2.1. Debates on the Necessity, Safety, and Cost-Efficiency of Water Reuse

In Germany, policy actors dispute whether wastewater reuse in agriculture is necessary, safe, and cost-efficient (I1, I2, I5).

For a long time, policy actors in Germany called into question the necessity of using treated wastewater for irrigation in agriculture (I5; Teiser, 2018). They argued that Germany is not an arid country, and, because of climate and soil quality, comprehensive irrigation of agricultural land is necessary only in few areas (Teiser, 2018). Only the cities of Braunschweig and Wolfsburg use treated wastewater for irrigation regularly in agriculture. The two exemptions are justified by traditional practices and specific soil conditions that impact agricultural production (I5). In recent years, the problems of water scarcity and aridity are receiving growing political attention. According to current data from the World Resources Institute (2020), Germany is among those European countries that are increasingly affected by medium-high levels of water stress. There is growing public concern that—fueled by the impacts of climate change—available water resources in Germany will further decrease in the future, especially in hot and dry summer months (Heggie, 2020). The issues of aridity and drought are also perceived of as challenges for agricultural policy, especially because of the increased risk of crop failure (BMEL, 2018b). In 2018, the Nature and Biodiversity Conservation Union (NABU; 2018) criticized the German agricultural sector for not being sufficiently prepared for dealing with the impacts of climate change. According to the NABU, agriculture in Germany needs to become much more compatible with nature and the climate to ensure resilience to extreme weather events (NABU, 2018). In the light of growing concerns about water scarcity and aridity, the issues of wastewater reuse in agriculture and related treatment technologies are gaining more attention in Germany.

The safety of water reuse is contested (I5). In May 2018, the UBA, responsible for scientific risk assessments concerning water affairs, published a list of questions and answers on the EU's proposal for the new regulation on minimum requirements for water reuse (UBA, 2018). While the UBA (2018) criticizes the proposal as not reaching far enough to guarantee safe use of wastewater in agricultural irrigation, wastewater treatment plant operators emphasize how strict the requirements are and that wastewater treatment plants must be upgraded to comply with the limit values (I5). The UBA demands risks that potentially arise from water reuse be taken into account. It criticizes that pollutants which can exist in treated wastewater, e.g., disinfection by-products, micropollutants, and peri- and poly-fluorinated alkyl substances (PFAS), are not considered by the common minimum requirements (UBA, 2018). The UBA also stresses possible negative effects on the environment. Persistent substances can accumulate in the soil and enter the groundwater through wastewater reuse in agriculture (UBA, 2018). Since the new EU regulation impacts agricultural production in Germany, it is surprising that we cannot find any comments on wastewater reuse in agriculture by the BMEL. This seems to indicate a missing connection between food and wastewater issues.

There are also critical debates on the cost efficiency of water reuse in agriculture (I1, I2). Even though water reuse technologies can treat wastewater to nearly any needed quality, advanced treatment involves high costs (Helmecke et al., 2020). In 2018, the German Alliance for Public Water Management (AöW), representing public operators of water supply, wastewater disposal, and river basin management, published a position paper commenting on the EU's proposal for water reuse. AöW (2018) favors water reuse only for areas with high water stress. It argues that additional costs for upgrading sewage treatment plants to meet the necessary requirements for agricultural irrigation should not be the concern of the operators of the treatment plants (AöW, 2018).

Interview data and focused stakeholder discussions also reveal the importance of financial aspects for operators of sewage treatment plants, as well as shifts in their self-perception (I1, I2, I5). As yet, only a few operators see themselves as providers of nutrients usable in food production. Financial incentives, such as financial relief for closing resource cycles (I1), could be drivers for the conversion of conventional sewage treatment plants into NEWtrient®-Centers. Sewage treatment plant operators depend on the acceptance of consumers, who pay for wastewater disposal and, thus, try to keep costs low (I1, I2). If it benefitted them financially, operators would probably be more open to applying new technologies, e.g., regarding fertilizer production (I2).

5.2.2. Risk Assessment and Minimum Quality Requirements for Water Reuse

Policy actors in the EU and Germany stress the issues of quality requirements and risks of water reuse in agriculture.

In 2017, the EFSA, in charge of scientific risk assessment regarding European food safety, was requested to review a draft report from the Joint Research Centre of the European Commission on the development of minimum quality requirements for water reuse in agricultural irrigation. The EFSA (2017, p. 11) points to negative impacts on human and animal health, stressing that "contaminated irrigation water is certainly a possible, and sometimes likely, source of pathogen contamination of fresh fruits, vegetables, animal feed and pastures." The EFSA (2017) recommends assessing the importance of the microbiological quality of irrigation water on human or animal illness caused by a specific pathogen before a minimum quality requirement for a specific hazard can be established. The EFSA (2017, p. 14) differentiates food crop categories and recommends making explicit "whether the edible part of the product will or will not be in direct contact with the irrigation water."

In Germany, the AöW (2018) and the UBA (2018) target risks of water reuse in agriculture. It is surprising that, so far, BMEL has not raised the issue since it is in charge of food safety and risk management and stresses that consumers need to be able to rely on the fact that what they eat is safe and harmless to their health (BMEL, 2020b). In April 2020, the BfR, which is mandated to conduct independent scientific risk assessments for BMEL, published a joint statement with the JKI and MRI on the risks of treated wastewater for fruit and vegetables for raw consumption. The research organizations propose a new directive setting minimum quality requirements for treated wastewater for use in agricultural irrigation (BfR, JKI, & MRI, 2020).

Our own survey results further substantiate the relevance of the issues of risk and minimum quality requirements. Responding to the question of which risks stakeholders perceive as most significant regarding the emerging technology, they name risks to human health first, followed by technological, environmental, economic, and social risks.

#### 5.2.3. Food Supply Chain Transparency and Labeling

Research findings reveal the relevance of debates on food transparency and labeling. Consumer research shows that, for German consumers, information on the origin and ingredients of food products is most important, followed by details on production and processing methods, and sustainability aspects (Nitzko, 2019). As yet, there is no labeling requirement in the EU for food products produced with treated wastewater. Thus, it is not transparent for consumers whether food has been produced or irrigated with treated wastewater (UBA, 2018). This is also criticized by policy actors from the water sector. AöW (2018, p. 3) states that it is "necessary for consumers to know, by means of appropriate labelling, which irrigation method was used in the production of agricultural products."

Our surveys reveal that stakeholders demand information about the emerging technology food production process, the safety of food products, risk control and management approaches, and benefits compared to conventional agriculture. The findings are confirmed by interview data. A food marketing expert underlined the importance of informing consumers about the new technology to create acceptance of the production process and potentially higher food prices (I3). Consumers are especially attracted to foods they can feel good about eating (I4). The emerging technology, thus, should produce "food products with a story" (I4), telling consumers how food from the new production process is more sustainable than that from conventional agricultural production (I1, I3).

### *5.3. Food-Water-Technology Nexus Governance Implications*

Substantial and procedural policy adjustments are needed to facilitate the step-by-step transformation of conventional sewage treatment plants into resource suppliers for urban agricultural production. Empirical findings indicate that food safety standards will have to be adjusted to the new circumstance that food could be produced at sewage treatment plants in the future. Wastewater regulations will have to shift the focus to food policy issues (I5). Limit values for different contaminants of emerging concern are needed, because there is a huge difference between discharging treated wastewater into water bodies and recovering nutrients from wastewater for urban food production. There is also a need to realign regulatory responsibilities across sectors as approving and monitoring tasks of supervisory authorities—both food control and water authorities—will become much more complex (I1).

However, findings indicate that policy agents from the water and food sectors prefer working within their own sphere of control for now. There is a need to cross the lines of defined resorts and responsibilities. Water and food policies need to be more integrated to capture synergies, take advantage of complementarities, and avoid contradictions in regulatory efforts. These findings correspond with research on SDG implementation that stresses the importance of minimizing situations in which sustainability policies offset one another (Liu et al., 2015; Pradhan et al., 2017). Cross-sectoral governance should be implemented collaboratively by ministries of agriculture and forestry, environment, water and natural resources, fisheries and marine resources, and health (Sachs et al., 2019). Although interdepartmental, so-called inter-ministerial committees have been set up in Germany to deal with cross-sectoral issues that will pose challenges in the future, there is still room for maneuver.

## 6. Conclusion

Technology innovation is a cross-cutting component of the 2030 Agenda and an important pillar for the implementation of the SDGs. This study shows that the emerging SUSKULT technology has the potential to facilitate SDG implementation in Germany. Simultaneously, it creates cross-sectoral interlinkages and policy demands that substantiate the need for more integrated governance to ensure the smart use of technology in SDG implementation. What can be achieved in SDG implementation through technology innovation from a nexus perspective depends on various factors: the context, the issues, the actors and capacities involved, the constructiveness of the dialog, the availability of information (data and knowledge), and the political will (Carmona-Moreno et al., 2018).

As a means of accelerating the achievement of the SDGs, starting from the bottom up seems to be a promising approach. Bottom-up solutions underline the important role of the local context for sustainability transitions. Innovative technologies like the emerging SUSKULT technology necessitate appropriate infrastructure and governance frameworks based on investments, information, and capacities at the individual, systems and organizational levels (UN Environment Management Group, 2019). Governing related FWTN issues involves appropriate urban design and planning. Regarding the implementation of SDG 2, cities are the ones to provide services, to promote healthy diets and healthy food environments, and to create procurement processes that consider the need for supporting the consumption of healthy and safe food with a low environmental impact (Siragusa et al., 2020, p. 41). Local governments can also actively promote sustainable urban agriculture practices both at the individual level and through community projects (Siragusa et al., 2020, p. 41). Regarding the implementation of SDG 6, cities are responsible for delivering drinking water and wastewater services and are called upon to further increase wastewater treatment and water use efficiency. Cities that play a leadership role in SDG implementation by means of technology innovation can create incentives for other cities to follow. As Johnson (2020, p. 435) rightly points out, there is a long tradition of cities learning from each other that offers opportunity for sharing experiences around how best to integrate nexus thinking into urban planning and design.

The bottom up perspective is necessary but will not be sufficient to ensure SDG implementation. Findings point to the need for identifying synergies between sectors, jurisdictions, and technology innovations at different governance levels (global, national, local). Ongoing policy debates about the reuse of wastewater and existing water regulations in the EU and Germany reveal a different regulatory focus (protection of surface waters, groundwater, and soil) and regulatory gaps, and are mainly sector-driven. They widely neglect the possibility of using recovered nutrients from municipal wastewater in urban agricultural production and, so far, only address conventional (soil-based) production. Technology innovation offers the opportunity to reflect on co-benefits between sectors and governance levels but it also reveals a number of new FWTN challenges, policy demands, and future research tasks. Achieving the SDGs by means of technological innovation requires governance frameworks that align global, national, and local strategies and allow for the development of shared understandings of FWTN challenges, especially with regard to the risks related to new technologies. Findings point to the need for new institutional arrangements that address FWTN issues, enable user ownership and cooperation, as well as broader societal participation. Despite the best institutional efforts, integrated governance also depends on changes in the self-conception of policy actors and their willingness to take on authority beyond sectoral logics. If food is produced in NEWtrient®-Centers in the future, wastewater operators will be part of the food production process, just like the food producers will become involved in the wastewater cleaning processes.

Finally, findings point to the issue of preventing technology development from losing sight of the public interest. Social sciences can create ‘nexus forums’ (Cairns & Krzywoszynska, 2016) where stakeholders discuss different understandings of FWTN challenges and offset power imbalances. The emerging technology is developed in a joint project where public and private sector actors, research institutions, and local stakeholders jointly advance cross-sector research and development. The participatory research approach allows feedback loops between theory and practice and participation of stakeholders in the development of research questions, concepts, and technologies. Stakeholder participation will considerably impact the implementation of scientific results to respond to global sustainability challenges and is likely to increase the future effectiveness and legitimacy of the emerging technology.

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## Conflict of Interests

The authors declare no conflict of interests.

## References


Becker, D., Frey, A., Jungfer, C., Krömer, K., Kulse, P., Maaßen, S., . . . Zimmermann, M. (2017). *Marktpotenziale der Wasserwiederverwendung: Anforderungen und Kriterien in unterschiedlichen Sektoren und mögliche Zielmärkte für das MULTI-ReUse-Verfahren* [Market potential of water reuse: Demands and criteria in different sectors and target markets for the *MULTI-ReUse* procedure] (ISOE-Materialien Soziale Ökologie 49). Frankfurt: ISOE.

Cairns, R., & Krzywoszynska, A. (2016). Anatomy of a buzzword: The emergence of 'the water-energy-food nexus' in UK natural resource debates. *Environmental Science & Policy*, *64*, 164–170.

Carmona-Moreno, C., Dondeynaz, C., & Biedler, M. (2018). *Position paper on water, energy, food and ecosystems (WEFE) nexus and Sustainable Development Goals (SDGs).* Luxembourg: Publications Office of the European Union.

Drewes, J. E., Becker, D., Jungfer, C., Krömer, K., Mohr, M., Nahrstedt, A., . . . Zimmermann, M. (2018). Mindestanforderungen an eine Wasserwiederverwendung: Hinweise aus Sicht der WavE-Forschungsprojekte des Bundesministeriums für Bildung und Forschung (BMBF) [Minimum requirements for water reuse: Comments from the research project WavE funded by the German Federal Ministry of Education and Research]. *gwf Wasser | Abwasser*, *12*, 1–10.

Endo, A., Tsurita, I., Burnett, K., & Orencio, P. M. (2017). A review of the current state of research on the water, energy, and food nexus. *Journal of Hydrology: Regional Studies*, *11*, 20–30.

EU. (1991). *Council Directive 91/271/EEC of 21 May 1991 concerning urban waste-water treatment*. Brussels: EU.

EU. (1993). *Council Regulation (EEC) No. 315/93 of 8 February 1993 laying down Community procedures for contaminants in food*. Brussels: EU.

EU. (1998). *Commission Directive 98/15/EC of 27 February 1998 amending Council Directive 91/271/EEC with respect to certain requirements established in Annex I thereof*. Brussels: EU.

EU. (2000). *Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy*. Brussels: EU.

EU. (2002). *Regulation (EC) No. 178/2002 of the European Parliament and of the Council of 28 January 2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety*. Brussels: EU.

EU. (2004). *Regulation (EC) No. 852/2004 of the European Parliament and of the Council of 29 April 2004 on the hygiene of foodstuffs*. Brussels: EU.

EU. (2006a). *Directive 2006/118/EC of the European Parliament and of the Council of 12 December 2006 on the protection of groundwater against pollution and deterioration*. Brussels: EU.

EU. (2006b). *Commission regulation (EC) No. 1881/2006 of 19 December 2006 setting maximum levels for certain contaminants in foodstuffs*. Brussels: EU.

EU. (2017). *Regulation (EU) 2017/625 of the European Parliament and of the Council of 15 March 2017 on official controls and other official activities performed to ensure the application of food and feed law, rules on animal health and welfare, plant health and plant protection products*. Brussels: EU.

EU. (2020). *Regulation (EU) 2020/741 of the European Parliament and of the Council of 25 May 2020 on minimum requirements for water reuse*. Brussels: EU.

European Food Safety Authority. (2012). *Science protecting consumers from field to fork*. Luxembourg: European Food Safety Authority.

European Food Safety Authority. (2017). *Request for scientific and technical assistance on proposed EU minimum quality requirements for water reuse in agricultural irrigation and aquifer recharge*. Luxembourg: European Food Safety Authority.

FAO. (2014). *The water-energy-food nexus: A new approach in support of food security and sustainable agriculture*. Rome: FAO.

Federal Environment Agency. (2014). *Arzneimittel und Umwelt* [Pharmaceuticals and the environment]. *UBA*. Retrieved from https://www.umweltbundesamt.de/themen/chemikalien/arzneimittel/humanarzneimittel/arzneimittel-umwelt

Federal Environment Agency. (2018). Questions and answers on water reuse. *UBA*. Retrieved from https://www.umweltbundesamt.de/en/topics/water/questions-answers-on-water-reuse#12.%20What%20does%20the%20German%20Environment%20Agency%20recommend?

Federal Environment Agency. (2019). *Mikroverunreinigungen in Gewässern* [Micropollutants in waterbodies]. *UBA*. Retrieved from https://www.umweltbundesamt.de/themen/wasser/wasser-bewirtschaften/mikroverunreinigungen-in-gewaessern#UBA-Empfehlungen

Federal Republic of Germany. (2004). *Verordnung über Anforderungen an das Einleiten von Abwasser in Gewässer (Abwasserverordnung–AbwV)* [German waste-water ordinance]. Berlin: Federal Republic of Germany.

Federal Republic of Germany. (2005). *Lebensmittel-, Bedarfsgegenstände- und Futtermittelgesetzbuch (Lebensmittel- und Futtermittelgesetzbuch—LFGB)* [German food and feed code]. Berlin: Federal Republic of Germany.

Federal Republic of Germany. (2009). *Gesetz zur Ordnung des Wasserhaushalts (Wasserhaushaltsgesetz—WHG)* [German water resources act]. Berlin: Federal Republic of Germany.

Federal Republic of Germany. (2016). *Verordnung über Anforderungen an die Hygiene beim Herstellen, Behandeln und Inverkehrbringen von Lebensmitteln (Lebensmittelhygiene-Verordnung—LMHV)* [German food hygiene regulation]. Berlin: Federal Republic of Germany.

German Alliance for Public Water Management. (2018). *AöW position to the European Commission's proposal for a regulation of the European Parliament and of the Council on minimum requirements for water reuse–2018/169(COD)* [Pamphlet]. Berlin: German Alliance for Public Water Management.

German Federal Institute for Risk Assessment, Federal Research Centre for Cultivated Plants, & Max Rubner-Institut. (2020). *Aufbereitete Abwässer: Bakterielle Krankheitserreger auf frischem Obst und Gemüse vermeiden* [Treated wastewater: Avoiding bacterial pathogens on fresh fruit and vegetables] [Pamphlet]. Berlin: German Federal Institute for Risk Assessment.

German Federal Ministry of Food and Agriculture. (2018a). *Understanding food safety: Facts and background*. Berlin: German Federal Ministry of Food and Agriculture.

German Federal Ministry of Food and Agriculture. (2018b). *Trockenheit und Dürre 2018: Überblick über Maßnahmen* [Aridity and drought 2018: Overview of measures]. *BMEL*. Retrieved from https://www.bmel.de/DE/themen/landwirtschaft/klimaschutz/extremwetterlagen-zustaendigkeiten.html

German Federal Ministry of Food and Agriculture. (2020a). *Kontaminanten in Lebensmitteln: Welche Rechtsgrundlagen gelten?* [Contaminants in food: Which legal rules apply?]. Berlin: German Federal Ministry of Food and Agriculture.

German Federal Ministry of Food and Agriculture. (2020b). *Gesunde Ernährung, sichere Produkte* [Healthy diet, safe products]. Berlin: German Federal Ministry of Food and Agriculture.

Heggie, J. (2020). *Die Zukunft des Wassers in Deutschland* [The future of water in Germany]. *National Geographic*. Retrieved from https://www.nationalgeographic.de/umwelt/die-zukunft-des-wassers-deutschland

Helmecke, M., Fries, E., & Schulte, C. (2020). Regulating water reuse for agricultural irrigation: Risks related to organic micro-contaminants. *Environmental Sciences Europe*, *32*. https://doi.org/10.1186/s12302-019-0283-0

High-Level Political Forum on Sustainable Development. (2018). *President's summary of the 2018 High-Level Political Forum on Sustainable Development*. New York, NY: High-Level Political Forum on Sustainable Development.

Johnson, C. (2020). Urban metabolism and new urban governance. In R. Bleischwitz, H. Hoff, C. Spataru, E. van der Voet, & S. D. VanDeveer (Eds.), *Routledge handbook of the resource nexus* (pp. 427–438). London and New York, NY: Routledge.

Lazarova, V., Asano, T., Bahri, A., & Anderson, J. (Eds.). (2013). *Milestones in water reuse: The best success stories*. London: IWA Publishing.

Liu, J., Mooney, H., Hull, V., Davis, S. J., Gaskell, J., Hertel, T., . . . Li, S. (2015). Systems integration for global sustainability. *Science*, *347*(6225). https://doi.org/10.1126/science.1258832

Martinez, P., Blanco, M., & Castro-Campos, B. (2018). The water-energy-food nexus: A fuzzy-cognitive mapping approach to support nexus-compliant policies in Andalusia (Spain). *Water*, *10*(664), 313–329.

Miller, E. L., Nason, S. L., Karthikeyan, K. G., & Pedersen, J. A. (2016). Root uptake of pharmaceuticals and personal care product ingredients. *Environmental Science & Technology*, *50*(2), 525–541.

Nature and Biodiversity Conservation Union. (2018). Dürre-Nothilfen an naturverträglichen Umbau der Landwirtschaft knüpfen [Linking drought emergency aid to nature-compatible agricultural restructuring]. *NABU*. Retrieved from https://www.nabu.de/news/2018/08/25053.html

Neubert, S. (2003). *Die Nutzung von Abwasser in der Landwirtschaft aus der Perspektive verschiedener Akteure: Umsetzungshemmnisse und mögliche Strategien in Tunesien* [Wastewater reuse in agriculture from the perspectives of different actors: Implementation obstacles and potential strategies in Tunisia]. Bonn: Deutsches Institut für Entwicklungspolitik.

Nilsson, M., Chisholm, E., Griggs, D., Howden-Chapman, P., McCollum, D., Messerli, P., . . . Stafford-Smith, M. (2018). Mapping interactions between the sustainable development goals: Lessons learned and ways forward. *Sustainability Science*, *13*, 1489–1503.

Nitzko, S. (2019). Consumer requirements for food product transparency. *Ernaehrungs Umschau international*, *66*(10), 198–203.

Pigford, A.-A. E., Hickey, G. M., & Klerkx, L. (2018). Beyond agricultural innovation systems? Exploring an agricultural innovation ecosystems approach for niche design and development in sustainability transitions. *Agricultural Systems*, *164*, 116–121.

Pradhan, P., Costa, L., Rybski, D., Lucht, W., & Kropp, J. P. (2017). A systematic study of Sustainable Development Goal (SDG) interactions. *Earth's Future*, *5*, 1169–1179.

Prosser, R. S., & Sibley, P. K. (2015). Human health risk assessment of pharmaceuticals and personal care products in plant tissue due to biosolids and manure amendments, and wastewater irrigation. *Environment International*, *75*, 223–233.

Riemenschneider, C., Al-Raggad, M., Moeder, M., Seiwert, B., Salameh, E., & Reemtsma, T. (2016). Pharmaceuticals, their metabolites, and other polar pollutants in field-grown vegetables irrigated with treated municipal wastewater. *Journal of Agricultural and Food Chemistry*, *64*(29), 5784–5792.

Sachs, J. D., Schmidt-Traub, G., Mazzucato, M., Messner, D., Nakicenovic, N., & Rockström, J. (2019). Six transformations to achieve the Sustainable Development Goals. *Nature Sustainability*, *2*, 805–814.

Schwindenhammer, S. (2017). Global organic agriculture policy-making through standards as an organizational field: When institutional dynamics meet entrepreneurs. *Journal of European Public Policy*, *24*(11), 1678–1697.

Schwindenhammer, S. (2020). The rise, regulation and risks of genetically modified insect technology in global agriculture. *Science, Technology and Society*, *25*(1), 124–141.

Siragusa, A., Vizcaino, P., Proietti, P., & Lavalle, C. (2020). *European handbook for SDG voluntary local reviews*. Luxembourg: Publications Office of the European Union.

Teiser, B. (2018). Erfahrungen aus der Abwassernutzung auf landwirtschaftlichen Flächen [Experience with wastewater reuse on agricultural land]. In S. Schimmelpfennig, J. Anter, C. Heidecke, S. Lange, K. Röttcher, & F. Bittner (Eds.), *Bewässerung in der Landwirtschaft* [Irrigation in agriculture] (pp. 47–58). Braunschweig: Thünen Institute.

United Cities and Local Governments. (2019). *Towards the localization of the SDGs*. Barcelona: United Cities and Local Governments.

UN. (2015). *Transforming our world: The 2030 agenda for sustainable development* (A/RES/70/1). New York, NY: UN.

UN Conference on Trade and Development. (2017). *The role of science, technology and innovation in ensuring food security by 2030*. Geneva: UN Conference on Trade and Development.

UN Environment Management Group. (2019). *EMG nexus dialogue on sustainable infrastructure: Outcome statement*. Geneva: UN Environment Management Group.

UN Interagency Task Team on Science, Technology and Innovation for the SDGs. (2018). *Science, technology and innovation for SDGs roadmaps*. New York, NY: UN Interagency Task Team on Science, Technology and Innovation for the SDGs.

Weitz, N., Strambo, C., Kemp-Benedict, E., & Nilsson, M. (2017). Closing the governance gaps in the water-energy-food nexus: Insights from integrative governance. *Global Environmental Change*, *45*, 165–173.

White, D. D., Jones, J. L., Maciejewski, R., Aggarwal, R., & Mascaro, G. (2017). Stakeholder analysis for the food-energy-water nexus in Phoenix, Arizona: Implications for nexus governance. *Sustainability*, *9*(12). https://doi.org/10.3390/su9122204

World Resources Institute. (2020). Aqueduct: Country rankings. *World Resources Institute*. Retrieved from https://www.wri.org/applications/aqueduct/country-rankings/?indicator=bws

Xie, M., Kyong Shon, H., Gray, S. R., & Elimelech, M. (2016). Membrane-based processes for wastewater nutrient recovery: Technology, challenges, and future direction. *Water Research*, *89*, 210–221.

Yillia, P. T. (2016). Water-energy-food nexus: Framing the opportunities, challenges and synergies for implementing the SDGs. *Österreichische Wasser- und Abfallwirtschaft*, *68*(3/4), 86–98.

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